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	Pleurolepis.	Alvordius.	Boleosoma.	Pœcilichthys.	Percina.	Nanostoma.	Etheostoma.	Boleichthys.	Microperca.
3. Neuroptera	07	79	23	42	17		27	63	02
Ephemeridæ	07	75	08	32	09		27	63	02
Pupæ		08		14					
Larvæ	07	63	08	18	09		27	63	02
Palingenia		04							
Agrionini (pupæ)		04							
Phryganeidæ (larvæ)			15	10	08				
III. CRUSTACEA		01	04		33		12		64
1. Amphipoda					03				12
Gammarus, yg									06
Crangonyx "									06
Allorchestes dentata Sm.					03				
2. Ostracoda					01				06
Cyprididæ					01				06
Undetermined					01				
Cypris									
3. Cladocera					24				27
Undetermined					05				
Daphniidæ					06				
Daphnia					07				
Sididæ					05				
Daphnella					05				
Lynceidæ					01				03
Chydorus									24
Eurycercus					01				
4. Copepoda		01	04		05		12		19
Cyclops		01	04		05		12		19
Confervoid Algæ					01				

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ON THE FORMER EXTENT OF THE TRIASSIC FORMATION OF THE ATLANTIC STATES.[1]

BY ISRAEL C. RUSSELL.

NEARLY two years since I read a paper before the New York Academy of Sciences, on the Physical History of the Triassic Formation in New Jersey and the Connecticut valley,[2] in which many reasons were given for concluding that the Triassic rocks of these two regions were detached portions of one estuary formation.

As several papers have been published relating to the Triassic rocks of the Atlantic States since my essay was written, increasing our knowledge of the subject, and as my interpretation of the geological records has not been accepted by some geologists, I take the present opportunity to briefly restate the substance of my former paper which seems to have been partially misunderstood, together with a brief review of the evidence that has since been gathered.

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[1] Read before the New York Academy of Sciences, March 22, 1880.

[2] Annals of the N. Y. Acad. of Sci., Vol. 1, No. 8 (1878), pp. 220–254.

The broad generalization advanced in the essay mentioned above, was, that all the detached areas of Triassic rocks, from South Carolina northward to Connecticut and Massachusetts, are portions of one great estuary deposit, which has been broken up into separate areas by upheaval and denudation. The immediate aim of the paper, however, was to prove the former connection of the Triassic rocks of New Jersey with those found in the Connecticut valley. The conclusion arrived at from the study of the rocks of these two areas, was, that they are the marginal portions of an estuary deposit, the central region having been subsequently upheaved and greatly eroded. The Triassic rocks in this region thus fill a synclinal trough, the longer axis of which has been upheaved into a broad anticlinal. The facts that lead to this conclusion may be briefly stated as follows:

First. The Triassic rocks in New Jersey dip to the westward at an average angle of about fifteen degrees, while the corresponding beds along the Connecticut river are inclined to the eastward at a somewhat larger angle; thus suggesting that they are portions of one great anticlinal.

Second. Each area is an incomplete estuary formation, having only one line of shore deposits. This is shown in the case of the New Jersey area by the fact that all along the line of bluffs bordering the formation on the west occurs a coarse conglomerate which we have shown to be a shore deposit, derived from the bluffs of crystalline rock to the westward. In the finer sandstones and shales associated and interstratified with this conglomerate are ripple marks, sun cracks, raindrop impressions and the footprints of animals, proving beyond question that this was the shore of the basin in which the Triassic rocks were deposited. Throughout the eastern margin of the New Jersey area, which is sharply defined along the western bank of the Hudson from Jersey City northward to Stony Point, these indications of shore conditions are entirely lacking, in their stead there are sandstones, slates and shales of the character of ordinary off-shore deposits. The trap rock forming the Palisades will be noticed farther on.

Crossing to the Connecticut valley we find this order reversed; on the eastern margin of this area the coarse conglomerates again occur, together with an abundance of all the other proofs of shore conditions we have mentioned; on the western margin the rocks have been formed of sand and mud deposited at a distance from the shore, and are without sun cracks, footprints, etc.; these beds correspond with the sedimentary rocks in the escarpment along the western shore of the Hudson. From these facts it seems perfectly justifiable to conclude that the variegated conglomerate bordering the New Jersey area on the west, corresponds in character and position with the coarse conglomerate occurring along the eastern margin of the Connecticut River region, thus mapping out portions of the eastern and western shores of the estuary in which the Triassic rocks were deposited.

Thirdly. The occurrence of an outlying mass of Triassic beds in the towns of Southburg and Woodbury, Conn., lying between the two great areas, also favors the conclusion that the sandstones and shales of New Jersey and the Connecticut valley were once united. This little oasis in the valley of the Housatonic, is but six or seven miles long by two broad, and is separated from the Connecticut valley area by fifteen and from the Hudson by forty miles of crystalline rock.[1]

Fourthly. The topographical features along the western margin of the New Jersey area and the extension across the Hudson of the line of bluffs which border the formation in New Jersey, as stated on page 21 of the writer's previous essay (page 241 of the Annals), also indicates that the Triassic rocks of New Jersey at one time followed the course of this old shore line and extended eastward of the Hudson.

Fifthly. The striking analogy that exists in the arrangement of the hills of trap found in these Triassic areas was also pointed out in the paper mentioned above. Nearly all the igneous rocks found in New Jersey and the Connecticut valley have been formed as sheets of molten matter intruded between the layers of sedimentary rock and have cooled and crystallized in that position. In the Connecticut valley these sheets of trap dip eastward at the same angle with the sandstones and shales, and present a bold escarpment to the westward; the ends of the long ridges are usually bent eastward so as to give them a "canoe-shape." In New Jersey the sheets of trap are inclined to the westward at an average angle of about fifteen degrees, and present their mural faces to the eastward, as in the Palisades along the Hudson. The trap ridges in New Jersey are also canoe-shaped, but have the ends bent to the westward.

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[1] Percival's Geo. Rep. of Conn., 1842, p. 410. Also Annals of N. Y. Acad. of Sci., Vol. 1, No. 8 (1878), p. 240.

From the study of these trap sheets we may derive important conclusions in reference to the former thickness and extent of the sedimentary rocks with which they are associated. We have previously shown that the long mountain-like ridges giving variety to the landscape in the Triassic areas of New Jersey and the Connecticut valley, are the outcropping edges of sheets of trap that have altered and metamorphosed the stratified rocks both above and below them.[1] From the slope which these outcropping sheets still show—to the westward in New Jersey and eastward in the New England area—it is evident that they were at one time inclosed in sedimentary strata, which have since been eroded away. That these sheets of trap did not reach the surface of the sedimentary beds is also evident from the fact that the molten material did not overflow and form table-lands, like those so common in New Mexico and other portions of the far West. On the First mountain, at Plainfield, New Jersey, as exposed along the Johnston drive, the baked and altered shale is still to be seen on the top of the trap ridge, three hundred feet above the general level of the surrounding plain; here we know that the trap ridge was entirely inclosed in beds of shale and sandstone, and at the very least three hundred feet of sedimentary beds have been removed by denudation. Extending the same reasoning to the Palisade range, we find that it too is a sheet of trap that cooled between strata of shale and sandstone; this conclusion is also borne out by the nature of the trap forming the Palisade range, which is dense and compact, showing that it cooled under pressure. This ridge of trap presents a continuous outcrop from Bergen Point, where it is but a few feet above tide water, northward to Haverstraw, when it attains an elevation of over a thousand feet. Are we not safe in concluding from this evidence that the sedimentary beds were once more than a thousand feet thick along the western bank of the Hudson, and that these same strata must have extended on to the eastward? Opposite New York city fully three hundred feet of sandstone and slate is exposed beneath the trap, their broken edges forming the shore of the Hudson at Weehawken. It is to be remembered in this connection also, that these beds were off-shore deposits and had an inclination of fifteen degrees to the westward.

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[1] On the Intrusive Nature of the Triassic Trap sheets of New Jersey. Amer. Jour. Sci., Vol. xv, April, 1878.

Sixthly. If we could arrive at definite results in reference to the present rate of erosion of the Triassic rocks, we could form more accurate conclusions as to the former thickness of this formation. We know, however, that the present waste, although the rocks are but little elevated above the sea, is very rapid. Composed of soft shale and sandstone, and highly inclined, these rocks present the most favorable conditions for rapid erosion; if these rocks have been exposed to subaerial denudation for a long time, it follows that an immense amount of material must have been removed.

The present drainage of the country shows that the upheaval of the Triassic beds was extremely gradual, and hence that they have been exposed to denudation for ages. The Delaware, for instance, flows at right angles to the strike of the rocks, and has carved out a broad *anticlinal* valley, about thirty miles in length, through the shales, sandstone and trap sheets of the Triassic. From this we must conclude that the Delaware flowed eastward through this region before the rocks were upheaved, and that the elevation of the beds went on so slowly that the river was enabled to cut out its channel as fast as the rocks were brought within its reach. The Susquehanna, the Potomac and other rivers to the south, also bear evidence to the slowness with which the Triassic rocks were elevated, and consequently to the great lapse of time during which they were exposed to subaerial erosion. The deep cañon-like valley of the Hudson, now partially filled, bears evidence of the same nature. No one who does not believe that the surface of the earth has always been as we see it to-day, can resist the conclusion that the Triassic rocks must at one time have had a very great thickness. The problem of measuring the former extent and thickness of the Triassic rocks in feet is far from being determined; we can only conclude from the above considerations, as the time has been long and the rate of erosion rapid, that their former thickness must have been very great.

The material removed from the region separating the two Triassic areas under discussion, must have been composed of sandstone, slate and shale like the escarpments bordering the denuded area on either side, but did not include beds of trap, for as we have already shown the trap ridges are intrusive sheets derived from fissures in the crystalline rocks beneath the regions where they occur.

In my previous essay the statement is made that if faults do not exist in the Triassic beds of New Jersey, that we cannot reckon their thickness at less than 25,000 feet. Under the same supposition the Triassic formation in Pennsylvania have been calculated to be 51,500 feet thick. In the notice of my paper which appeared in the *American Journal of Science*,[1] the first three objections to my conclusions are based on the misconception of this statement. As to the fourth objection, that the "northern limit of the Connecticut valley sandstone area is *north of the northern* limit of the New Jersey. The New Jersey area cannot, therefore, be on the opposite margin of the sandstone region to that of the Connecticut valley," the fact is overlooked that the relative position of these two areas has been determined by the direction of the axis of upheaval of the central region and by the accidents of erosion. Were the Triassic rocks in New Jersey entirely removed, those found to the southward, in Pennsylvania and Virginia, would still be portions of the western margin of the deposit, opposite to that found in the Connecticut valley.

In objection number five of the review, the sweeping statement is made that "no evidence of such an anticlinal, or of the supposed amount of erosion, exists excepting this—that the sandstone of the Connecticut valley dip eastward, and that of New Jersey, situated wholly to the south of the southern limit of the Connecticut valley area, dip northwestward, at the angle stated." The only reply that can be made to this, is simply to refer to the remaining lines of evidence converging on the same point.

It is puzzling to know how "violent floods of the Connecticut river, enlarged for a part of the time by the waters and ice of a semi-glacial era" could spread out wedge-shaped masses of coarse conglomerate along the eastern margin of the Triassic formation, the material forming the conglomerate being clearly derived from the shores of crystalline rock against which the bases of these wedge-shaped masses rest. As we go westward from the old shore line these beds of conglomerate thin out and pass into the finer off-shore deposits; associated with the conglomerate we also find an abundance of footprints, rain-drop impressions, etc. On the western margin of the same area these proofs of shore conditions are wanting. If this is a river, or a narrow estuary deposit we should expect to find somewhat similar strata on each side of the valley, and that the material forming the rocks should become coarser as we go northward, which as the geological surveys show is not the case; then, too, what river with floods and ice-rafts spread out the Triassic beds in New Jersey, which extend in one unbroken area far into Virginia, with the same structural peculiarities as are found in the Connecticut valley but reversed in their relative position.

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[1] *Amer. Jour. Sci.*, April, 1879, pp. 328–330.

Since my essay on the Physical History of the Triassic Formation was written, an interesting and valuable paper on the "Mesozoic Formation of Virginia"[1] has been published by M. O. J. Heinrich, in which many facts are given that have a direct bearing on the question of the former extent of the Triassic formation. The map accompanying this essay gives the position of the detached areas of Triassic rocks in Virginia and North Carolina, together with the dip of the beds, and suggests very strongly that the separate patches were once united. This conclusion presented itself to Mr. Heinrich also, as on page 23 of his paper we read, "the destruction of a connection formerly existing between all the Mesozoic deposits along the Atlantic States might, therefore, be attributed to a slow, an unequal rising of the Eozoic rocks after the deposition of the former upon the uneven floor of the latter, noticed in the anticlinal of the latter, and producing an unequal denudation of the Mesozoic deposits." In the carefully-prepared section of the Richmond coal basin, published with this paper, we find a rapidly-alternating series of sandstones, shales and coal, 1518 feet thick, including a coarse conglomerate thirty-six feet thick at the bottom of the series. This section shows that the conditions at the time of the deposition of these beds was not unlike those now prevailing at the northern end of the Bay of Fundy, where the Tantra marshes are forming.

Another paper on the "Mesozoic of Virginia," by Prof. Wm. M. Fontaine, published in the *American Journal of Science* about a year since,[2] contains much interesting and valuable matter, but

[1] Transactions Amer. Inst. Mining Engineers, 1878.

[2] *Amer. Jour. Sci.*, January, 1879.

arrives at conclusions in reference to the formation of the Triassic conglomerates, the climate of the Triassic period, etc., that seem at variance with the facts, at least as presented in the northern areas of Triassic rocks. The conclusion that the conglomerates are of glacial origin, as also suggested by Prof. Dana,[1] is not sustained by the structure of the variegated conglomerate in New Jersey.

The view that the Appalachian Mountain region was of sufficient height to become covered with perpetual snow, and give rise to glaciers which terminated in the sea, and brought down as moraines the material forming the Triassic conglomerates, and also that the paucity of animal remains in the Triassic rocks is due to the low temperature of the water, owing to the supposition that " the Mesozoic area was fed by the cold waters issuing from the ice and snow of the mountains," is open to several serious objections:

First. The conglomerate, at least in New Jersey and the Connecticut valley, is of the nature of an ordinary shore deposit, formed mostly at the mouths of streams.

Second. The boulders in this conglomerate are smoothed and rounded, but do not show grooves, scratches or planed surfaces like the stones to be found in a moraine.

Thirdly. The fossil plants occurring in these rocks are ferns, cycads, equiseta and coniferous trees of the Araucarian family, these are found from North Carolina northward at least as far as Connecticut and Massachusetts; the home at the present day of the plants belonging to these families, especially of the Cycads and Araucarias, is in tropical and sub-tropical regions.

Fourthly. There was an abundance of reptilian life in Triassic times, as is shown by the great number of footprints found both in New Jersey and the Connecticut valley; reptiles of large size also lived as far northward as the Prince Edward islands. All the larger reptiles of the present day are confined to the warmer regions of the globe, and are mostly found within the tropics. We can hardly believe that the gigantic reptiles of the Triassic age were so different in habits from their modern representatives that they could find a congenial home along shores that were covered with ice, or in waters derived from the melting of glaciers in which icebergs were floating.

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[1] *Amer. Jour. Sci.*, April, 1879, p. 330.

The absence in the Triassic rocks of the peculiar markings that are made in soft mud when it freezes, and which are as capable of being preserved as are rain-drop impressions or footprints, is another although a negative indication that there was a mild climate in the Eastern States during the Triassic period.

Then, too, there was not a "paucity of animal life" in Triassic days, as thousands of footprints show; the waters of the estuary were also inhabited by immense numbers of fishes, some of them of considerable size. As to the absence of molluscan life owing to the coldness of the waters, we know that many species of Arctic shells are found in the mud at the foot of the glaciers that terminate in the sea in high latitudes, and that the same and allied species are found in the glacial clays both of Europe and America, thus showing that the presence of ice could not account for the absence of molluscan remains in the Triassic formation. The absence of shells in these rocks seems due to the fact, long since pointed out by Sir H. De la Beche,[1] that animals which live on the sea bottom cannot exist upon a bottom of red mud, and that the presence of peroxide of iron in the waters is fatal to animal life; the presence of peroxide of iron in the rocks will also promote the rapid decomposition of such organic remains as may become imbedded in them. All who have wandered along the shores of the Bay of Fundy, where the bottom is composed of red mud, will remember how destitute they are in mollusks, radiates and crustaceans, the waters are inhabited, however, by great numbers of fishes, belonging, I believe, to a limited number of species. Thus in almost every particular, the study of the present condition of the Bay of Fundy furnishes us with the key with which to unlock the history of the Triassic formation.

The information added by the papers of Mr. Heinrich and Prof. Fontaine, tends to confirm the conclusion that the Triassic rocks in the Atlantic States were formed in one estuary, in the northern end of which sandstone and shales were deposited, being subjected to a greater subsidence than the southern extremity, where the shores were low and favorable for the accumulation of carbonaceous mud and peat.

As the determination of the age of the rocks in question from the fossil plants they contain, has led to widely varying results, we have continued to call them Triassic. If the view here presented of their former extent is sustained, it is evident that the separate members are of one age, differing in their lithology and fossils according to the various conditions under which they were deposited.

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[1] Memoirs of the Geological Survey of Great Britain, Vol. I, p. 51.

NOTE.—Although the conclusions given in my former paper were arrived at independently, I find that the same explanation of the dip of the rocks has presented itself to others. Prof. Hitchcock in his work on the "Ichnology of Massachusetts," p. 14, in speaking of the opposite dip of the beds in New Jersey and the Connecticut valley, says, "It looks rather as if an anticlinal axis or elevation between them, had been concerned in the tilting of both." Prof. Kerr, in his report on the geology of North Carolina, page 141, accounts for the separation of the Deep and Dan river Triassic areas by the upheaval of the region lying between, and the removal of the Triassic beds by denudation, the parts remaining are the fringing portions of a great anticlinal. Prof. Bradley, in an article "On the Geological Chart of the United States east of the Rocky mountains" (*Amer. Jour. Sci.*, Vol. XII, p. 289), favors Prof. Kerr's conclusion and suggests that the numerous trap dikes intersecting the metamorphic rocks of North Carolina, South Carolina, Georgia and Alabama, may belong to the Triassic series and indicate the former extension of this formation southward; the dip of the beds in New Jersey and the Connecticut valley also attracted his attention and suggested the former connection of these two areas.

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NOTES ON STONE IMPLEMENTS FOUND IN NEW JERSEY.

BY CHAS. C. ABBOTT, M.D.

THE recent article by Prof. Perkins in the January NATURALIST[1] suggests the propriety of my making a brief reference to certain forms of stone implements which have been found in New Jersey since the date of the publication of the Smithsonian Annual Report for 1875;[2] and particularly to the occurrence of such

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[1] Archæology of the Champlain valley. By Prof. Geo. H. Perkins.

[2] January, 1877. It may be well to state that the MSS. of my paper was completed in Dec., 1873, and during the six years ensuing, I have gathered fully twelve thousand additional specimens. None of these are referred to in the Smithsonian Report for 1875.